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DESIGN OF A REAL TIME AUTO WATER SAVING IRRIGATION SYSTEM BASED ON µC/OS-II AND ZIGBEE NETWORK

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ABSTRACT

The increasing shortage of water around the world today is an important problem, so an efficient water management is very important especially in agriculture field. There are many embedded platform based irrigation control systems are available, but the major drawback of such systems are their inability to handle multiple tasks. The reliability and processing capability of the systems are greatly improved by adding the Real Time Operating System (RTOS), that provides real-time multi-tasking capabilities to the system. This paper proposes an embedded platform based on µC/OS-II RTOS and Atmega128 AVR microcontroller, which has a Wireless Sensor Network (WSN) using ZigBee technology, for real time in field sensing and control of an irrigation system.

KEYWORDS: RTOS, WSN, Irrigation, Multi-Tasking, ZigBee

1. INTRODUCTION

Water is the most important element in our life. Without it, we cannot survive. In a country like India where economy is mainly based on agriculture, still we are not being able to make full use of agricultural resources [1]. Water and agricultural production are inseparable and with the development of social economy, the requirements for irrigation quality, safety, and reliability are becoming more prominent. Irrigation capability has a direct impact on crop growth and people's needs, thus to ensure a low-cost, reliable and efficient operation of the irrigation equipment become the main direction of technology of improving agricultural systems in recent years [2]. The main reason behind such situation is the scarcity of water, so an efficient water management system is necessary. At present in India farmers have been using manual irrigation system, in which farmers irrigate the land manually at regular intervals. This type of irrigation consumes more amount of water or it may sometime causes the water to reach the crop root zone late, that will causes the crops get dried. The moisture content in the soil has a great impact on plant growth, reproduction and photosynthesis. So, getting information about moisture content in soil, effectively and accurately plays an important role in guiding water-saving irrigation in agriculture field. In traditional soil moisture monitoring system, the software programming usually has no operating system; such kind of system has many limitations on system stability and real-time functions. The basic idea behind the proposed system is to design an auto water saving irrigation system based on a real time operating system, that will automate the manual irrigation system and ensure right amount of water at right time in the agriculture field. The rest of the paper is structured as follows. Section 2 introduces proposed system and its working. In Section 3 we will discuss about our hardware design of system. In Section 4 we will describe software design of system. And finally in Section 5 we concluded with results and discussions.

2. PROPOSED SYSTEM

The block diagram of the proposed system is shown in Figure 1 the proposed system has two units one is the Field station unit and other is the Base station unit. The field station unit consists of wireless sensor network (WSN) [3] for gathering environmental data in the agriculture field such as soil moisture, air temperature and humidity; and auto irrigation control unit for controlling the actuator section and also it will act as the coordinator node in the wireless sensor network. And the gathered parameters will be wirelessly transmitted to the base station unit using ZigBee technology [4], base station unit is a server PC. In the base station unit, user is able to monitor the environmental parameters and send the control commands to the field station unit using ZigBee technology in order to control the actuator section

Wireless Sensor network has playing a vital role in the agriculture field especially in the irregular farmlands where the field consisting of both slope and plain areas [5]. So the assignment of sensor node in the agriculture field is very important, the sensor nodes are arranged in the field based on some topographical data such as soil texture, soil water content, elevation and slope of lands and so on. So for regular farmlands one sensor node is enough but for irregular farmlands more than one sensor nodes are needed [3]. Then only we can provide uniform and sufficient level of water supply to the irrigation field.

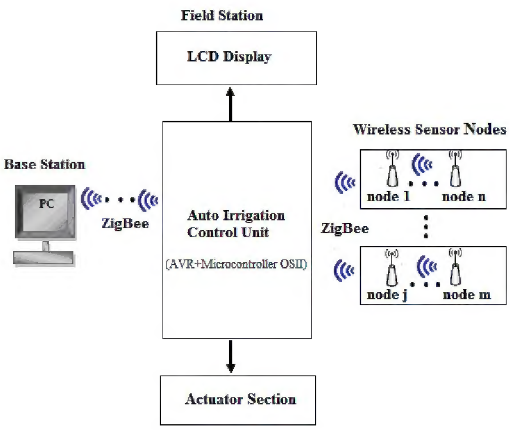

Figure 1: Block Diagram

3.HARDWARE DESIGN OF THE SYSTEM

3.1 Auto Irrigation Control Unit and MCU Unit

The proposed system design adopts an AVR AT mega 128 series microcontroller with embedded µC/OS-II Real time operating system, the reliability and processing ability of the system are improved greatly by adding the µC/OS-II operating system, which brings real-time multi-task processing capabilities [6] [7] .

AT Mega 128 MCU Features

- Advanced RISC Architecture
- 128K Bytes of In-System Self-Programmable Flash
- 4K Bytes RAM
- Two Programmable Serial USART
- Eight external interrupts

- 8-channel, 10-bit ADC
- 32 General purpose working registers

µC/OS-II Features

- µC/OS-II is a portable, ROMable, Scalable, pre-emptive, real-time, deterministic, multitasking kernel for microprocessor, microcontrollers and DSPs.
- Pre-emptive multitasking real-time kernel with optional round robin scheduling
- Delivered with complete, clean, consistent, 100
- Up to 254 application tasks (1 task per priority level), and unlimited number of kernel objects
- Very Low Interrupt Disable Time
- Third party certifiable Mutual exclusion semaphores with built-in priority ceiling protocol to prevent priority inversions
- Highly scalable

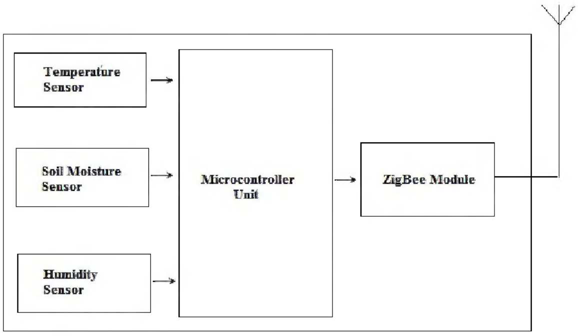

Figure 2: The Sensor Node Module

3.2 Sensor Node

The sensor node of Wireless Sensor Network (WSN) consist of sensors such as Temperature sensor, humidity sensor and soil moisture sensor, ZigBee module and an AVR microcontroller embedded with Microcontroller OSII. LCD Display can be included with each sensor node for in field sensor data monitoring. The hardware structure of system sensor node is shown in Figure 2.

Moisture sensor for soil adopts a soil moisture sensor circuit which follows the current sensing principle that is it detects and converts current to an easily measured output voltage, which is proportional to the current through the measured path. The moisture circuit designed here follows the direct sensing method that is measuring the voltage drop associated with the current passing through passive electrical components.

The environmental temperature sensor adopts LM-35 integrated-circuit temperature sensor. The LM35 is rated to operate over a −55°C to +150°C temperature range. The humidity sensor adopts SY-HS-220. The SY-HS-220 is rated to operate over 0-60°C temperature range and operating humidity range over 30-90%RH

The Zigbee, the RF module, is heart of the Wireless Sensor Node. It is a wireless transceiver supporting the IEEE 802.15.4 protocol. Low-Rate Wireless Personal Area Network protocol (LR-WPAN) for Wireless Sensor Networks (WSN) or for mesh networking use ZigBee or DigiMesh. This allows addressable communications between nodes. Data may be sent to individual nodes (point-to-point), or to all nodes in range (point-to-multipoint) using a broadcast address.

3.3 Controlling and Actuator Section

Solenoid valve is used as the main actuator element. It is a power-operated devices used to modify fluid flow or pressure rate in a process system. Quick opening of valves that consist of a metal circular disc at right angles to the direction of flow in the pipe, which when rotated on a shaft, seals against seats in the valve body [5]. In greenhouses temperature can be controlled during the growth of the crops and also humidity can be controlled in order to prevent crop from seeding diseases [3].

4. SOFTWARE DESIGN OF SYSTEM

First of all, the system runs initialization functions of itself and µC/OS-II operating system, such as using EEPROM to restore system state set the initial value of each parameter, and read system t time from clock chip DS1307. Initialization task of operating system µC/OS-II include initializing all data structure, allocating memory space for stack and establishing semaphore message queue of inter-task communication Then we can create tasks and set different priority to each task. Once all tasks are ready, the system will execute them according to priorities. The system turns fully operational when the initialization is done. µC/OS-II operating system is a preemptive kernel that means the task that has a higher priority can preempt to run. Therefore, we need to set the task that needs quick response in ready state after entering the interrupt program, so that higher priority task can be run right after exiting the interrupt program [6]. In the proposed system the following priorities are assigned to each task, so the system will execute the tasks based on the assigned priorities

- For DS1307 RTC -priority is 1
- For Soil Moisture Sensor- priority 2
- For Humidity sensor- priority 3
- For Temperature sensor -priority 4
- For Data display- priority 5

Algorithm of the software implementation is as follows

- **Step 1:** Include header files such as “stdlib. h” "includes. h" and "LCDmega128.h"
- **Step 2:** Create Task and other sub functions.
- **Step 3:** Define Stack for each task
- **Step 4:** Define temporary variables and semaphore variables.
- **Step 5:** Create 5 tasks with appropriate priority. Task 5-priority 1(highest), task 3-priority 2, task 2-priority 3, task 1-priority 4, and task 4-priority 5(lowest).

- **Step 6:** Go to higher priority task; task 5 and check for any desired key press, if yes go to step 7 else go to step 8.
- **Step 7:** Perform operations for RTC output display and also transmit it to server -Task 5
- **Step 8:** Measure moisture content and transmit it to server , if the moisture content is below the preset low threshold value the valve will turned ON automatically and remains in that position until it reaches the preset high threshold value -Task 3
- **Step 9:** Measure Humidity and transmit it to server-Task 2
- **Step 10**: Measure temperature and transmit it to server -Task 1
- **Step 11**: Display moisture, humidity and temperature in LCD screen -Task 4
- **Step 12**: Repeat operations from step 6

An overview of the software implementation is as shown in Figure 3.

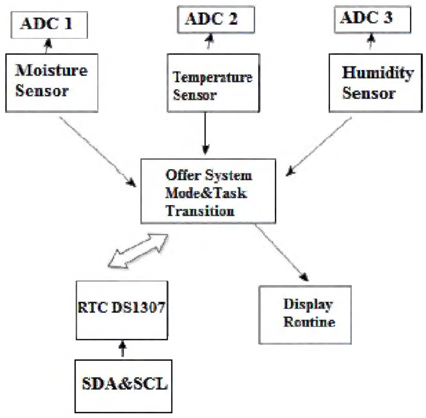

Figure 3: Software Structure

5. RESULTS AND DISCUSSIONS

On giving power to the system, the sensors start their operation and user can view these sensor values from the GUI. Auto water saving irrigation system is a highly secure password protected system .In order to view the physical condition of the agriculture field the user need to enter the password and click on the connect tab in the GUI.

The proposed system has two modes. One is the Manual mode and other is the Auto mode .In Manual mode user can manually turn on the solenoid valve by pressing the Valve ON box and the user can turn off the solenoid valve by pressing the Valve OFF box. To enter the Auto mode the user first press the connect button in the GUI and the user is now connected with the field station and now the user can see the temperature, humidity and moisture parameter from the field and the sensed values are displayed on the corresponding boxes, In Auto mode user can set the threshold values and also set the time. The valve will open when the sensed moisture values are below the Low threshold value and valve will close when the sensed moisture value is above the High threshold value. The green colour on Valve ON box indicates that valve is in ON position and red colour on Valve OFF box indicates that irrigation is stopped. Fig.4 shows the screen shot of GUI interface created in visual basic.

Figure 4: GUI for Proposed System

Figure 5 shows the prototype of the proposed system which displays the temperature, moisture and humidity. The developed prototype has been tested by monitoring the temperature, moisture and humidity parameters in a field from 7.00 AM to 6.00 PM in day. The soil which is under consideration has upper threshold value of 72% and lower threshold value of 45%.Each soil has a different threshold value. Table 1 shows the observations of the prototype during a day

Figure 5: Display of Proposed System

Table 1: Observation of Prototype in a Day

Sr. No.	Time of observation	Temper-ature	Humidity	Moisture	Valve positon
1	7.00 AM	24 °C	80%	72 %	OFF
2	9.00 AM	25 °C	67%	65 %	OFF
3	12.00 AM	27 °C	56 %	52 %	OFF
4	2.00 PM	28 °C	50 %	40 %	ON
5	4.00 PM	26 °C	50%	42 %	ON
6	6.00 PM	25 °C	55 %	54 %	OFF

6. CONCLUSIONS

The proposed system introduces real-time auto water saving irrigation system based on μC/OS-II and wireless sensor network. The prototype developed here is to overcome the shortcomings of commercial irrigation control system by considering the physical parameters such as air temperature, humidity and soil moisture content. The auto-saving water irrigation system can apply not only to the greenhouses but also regional farmlands and large irrigation area. The system adopts ATMega128 micro-processor, sets up an embedded platform based on ATMega128 and realizes some applications

such as wireless sensor network, sensor interfacing etc. The processor software is based on the embedded real- time OS and utilizes the multi task structure. Due to the µC/OS-II operating system, task scheduling is available, and the system's reliability, real-time capability and stability are greatly improved

FUTURE SCOPE

In the proposed work only some physical parameters such as air temperature, humidity and soil moisture content are measured. In the future the system can be elaborated by including more sensors like PH sensor, radiation and sunshine sensor, rain fall sensor,CO2 content sensor, intensity of illumination sensor etc, so that the system will be more efficient and more convenient to both greenhouses and farmlands. In the future work sensed data from the field can be uploaded to internet will help the farmer to monitor the field conditions from where he wanted and the inclusion of solar panel will reduces the power consumption of the system.

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